Measurements of Ocean Surface Backscattering Using an Airborne 94-GHz Cloud Radar—Implication for Calibration of Airborne and Spaceborne W-Band Radars

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(Manuscript received 10 May 2004, in final form 8 October 2004)

ABSTRACT

Backscattering properties of the ocean surface have been widely used as a calibration reference for airborne and spaceborne microwave sensors. However, at millimeter-wave frequencies, the ocean surface backscattering mechanism is still not well understood, in part, due to the lack of experimental measurements. During the Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment (CRYSTAL-FACE), measurements of ocean surface backscattering were made using a 94-GHz (W band) cloud radar on board a NASA ER-2 high-altitude aircraft. This unprecedented dataset enhances our knowledge about the ocean surface scattering mechanism at 94 GHz. The measurement set includes the normalized ocean surface cross section over a range of the incidence angles under a variety of wind conditions. It was confirmed that even at 94 GHz, the normalized ocean surface radar cross section, σ_o, is insensitive to surface wind conditions near a 10° incidence angle, a finding similar to what has been found in the literature for lower frequencies. Analysis of the radar measurements also shows good agreement with a quasi-specular scattering model at low incidence angles. The results of this work support the proposition of using the ocean surface as a calibration reference for airborne millimeter-wave cloud radars and for the ongoing NASA CloudSat mission, which will use a 94-GHz spaceborne cloud radar for global cloud measurements.

1. Introduction

Clouds play a critical role in the earth's climate system. The vertical structure and spatial distributions of clouds are important in determining the earth's radiation budgets, which affect global circulations and ultimately climate. However, the lack of finescale cloud data is apparent in current climate model simulations (Houghton et al. 1995; Stephens et al. 1990). Millimeter-wave cloud radars have gained favor for measuring the spatial distribution of clouds because of their high scattering efficiency, low power consumption, and compact size. A number of airborne millimeter-wave cloud radars have been developed (Pazmany et al. 1994; Sadowy et al. 1997; Li et al. 2004). Meanwhile, a 94-GHz spaceborne cloud radar is in preparation for the National Aeronautics and Space Administration's

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